McChesney and Tershy 1998). A careful review of the scientific literature makes it clear that murrelets have existed, and in some places continue to exist in highly altered ecosystems where natural processes have been disturbed (for example, Santa Barbara Island, see Figure 6). Though murrelets still exist at all known historical colonies, their numbers probably are greatly reduced from historic levels (see earlier discussion under Population Trend).

A further example of the human-altered nature of the Channel Islands ecosystem is the declining population of Island Foxes from excessive Golden Eagle (*Aquila chrysaetos*) predation. In an effort to protect the foxes, the Golden Eagles are being removed, because they did not historically nest on the Channel Islands. Bald Eagles (*Haliaeetus leucocephalus*) are being reintroduced, and their presence should restrict Golden Eagles, thus reducing Golden Eagle predation on foxes and allowing for fox recovery. The Bald Eagle was eliminated as a breeding bird on the Channel Islands, as was the Peregrine Falcon (*Falco peregrinus)*, due to the effects of DDT contamination (see discussion on peregrines in Threats section of this report).

Two other seabirds, the Tufted Puffin (*Fratercula cirrhata*) and the Common Murre have also been impacted on the Channel Islands, for reasons not well understood. Common Murres and Tufted Puffins have only recently returned to the Channel Islands in very small numbers (H.R. Carter, pers. comm.). Human impacts are suspected to have played a role in the decline of these two alcids (Hunt et al. 1979, Hunt et al. 1980).

<u>Summary</u>

The Department believes there is sufficient scientific information to indicate that many factors are negatively affecting the ability of the population to survive and reproduce. Additionally, as was noted earlier, the murrelet is naturally limited from occupying or expanding to the larger Channel Islands (San Miguel, Santa Cruz, Santa Catalina, and San Clemente) due to the presence of the Island Fox.

Threats

Threats to the murrelet have been divided into major and minor categories to help identify their degree and immediacy. Four major threats (non-native mammals, oil pollution, native predators, and artificial light pollution), and four minor threats (human disturbance at colonies, oceanographic and prey changes, disturbance and mortality from military operations, and bycatch in fisheries) have been identified and are discussed below. At this time, there is no information to suggest disease or competition are significantly affecting murrelet population viability, though these aspects of murrelet life history have not been well studied.

Bald Eagles are known to prey upon Xantus's Murrelets at Santa Catalina Island (H.R. Carter, pers. comm., via D. Garcelon). Reintroduction of eagles to the northern Channel Islands may lead to greater predation on Xantus's Murrelets. However, at this time, the Department has no information to indicate that Bald Eagles are an imminent or significant threat to murrelets.

The cumulative impact of these threats is an important consideration, and this was noted in the petition on page 13. The petition states: "*Although murrelet mortality from native predators may be viewed as a "natural" situation, the impact of such mortality must be considered as a factor additive to such "unnatural" mortality from anthropogenic sources and non-native animals. The so-called "naturalness" of current predation levels from native predators also must be assessed carefully, since long-term ecosystem changes (e.g., plant communities) likely have led to changes in predator populations and ecology. Thus, levels of predation may be much higher than they were historically.*" The Department supports this view, and we believe there is sufficient scientific information as was discussed and cited in the Population Trend section of this report. Further scientific information to support additive population effects is found in a comprehensive review paper on seabirds and predation (Burger and Gochfeld 1994:43). These authors state: "*The main point is that naturally occurring predators have not been implicated in eliminating major populations, although they may be important to relict populations reduced by other factors.*"

Threats can be additive and help to exacerbate population decline. For example, because the first egg of a murrelet clutch is left unattended until shortly after the second egg is laid, this provides an opportunity for mouse or rat predation on the unattended egg. Such a scenario is particularly important given the presence of a non-native predator, such as the black rat, or if mouse population density if high. As was noted earlier, there is substantial scientific literature on the negative effects of rat predation (see Population Trend section of this report).

Direct mortality of murrelets from oil spills, rat predation, or Barn Owl predation has a more obvious effect on population growth than human disturbance factors that do not result in direct mortality. However, consistent disturbance can reduce energy reserves by causing murrelets to move further or more often than they would normally, and disturbance can also result in nest abandonment. Murrelet eggs/nest sites could be unintentionally destroyed by human foot traffic, especially in sea caves where light levels are low and natural debris serves to camouflage nest sites.

Major Threats

Non-native Mammals

Rats are known to consume eggs, but also adults, and occasionally chicks of various seabirds throughout the world (Bertram 1995, Seto and Conant 1996, Drever and Harestad 1998, and others). Rats are well documented as causing population declines in seabirds (Springer et al. 1993, Bertram 1995, Seto and Conant 1996, McChesney and Tershy 1998, Seto et al. 2001, Sowls and Rauzon 2001, Ogle 2002, and others). Table 2 in the petition also documents the extensive presence of introduced rats and other non-native mammals at known murrelet breeding sites from California to Mexico. The Department is involved in a rat eradication program at Anacapa as a member of a trustee council, charged with carrying out and monitoring the results of the Anacapa restoration plan. A council was formed as a result of settlement of the American Trader oil spill case.

The rat removal at Anacapa Island may result in the eventual restoration of a potentially large murrelet colony (McChesney et al. 2000). The restoration of significant numbers of breeding murrelets on Anacapa Island via the rat removal project holds great promise. In other parts of the world, success stories are beginning to emerge as biologists undertake rat control projects. For example, rat eradication on Midway Atoll was initiated in 1994. Bonin Petrel (*Pterodroma hypoleuca*) colonies responded to rat control by increasing their reproductive success from zero to a high of 83%. Christmas Shearwater (*Puffinus nativitatis*) numbers have also increased dramatically since rat eradication (Seto and Conant 1996, Seto et al. 2001). Intensive predator management work in New Zealand has also produced positive results for the extremely rare Taiko Petrel (*Pterodroma magenta*) (Ogle 2002).

The lag time for substantial seabird response may be at least 6 years based on the Midway Atoll example, and longer (10-15 years or more) for highly endangered birds, such as the Taiko Petrel. Response time will depend on the extent of the eradication effort, the size of the seabird population at the time of predator control, and many other variables that can affect seabird population growth (for example, reproductive rate, mortality factors, food supply, weather, and the presence of other predators).

Given that alcids have high colony fidelity, there will likely not be a large influx of murrelets from other colonies to capitalize on a rat-free nesting environment. Thus, it may take 10 years or more to see substantial increases in nesting effort and reproductive success for murrelets at Anacapa Island.

Additionally, as was noted in the petition on pages 9-10, rats could be accidentally reintroduced onto Anacapa Island or other Channel Islands, thus, a management plan to combat future introductions is needed. Appendix E of this report contains two items: 1) a copy of an August 15, 1994 letter from the Pacific Seabird Group to the NPS expressing the need for a contingency plan for accidental rat introductions, along with other conservation suggestions; the reply letter back from the NPS is also included; 2) a copy of a July 26, 2000 letter from the Pacific Seabird Group to the U.S. Fish and Wildlife Service in support of the rat eradication effort at Anacapa Island.

Oil Pollution

There is the potential for injury and mortality to murrelets in the case of an oil spill or chronic oiling events. A few dead oiled Xantus's Murrelets have been reported on beaches in central California (Carter et al. 2000). Other than these few birds, there are no other known mortalities for Xantus's Murrelets from oil spill events. Seabird mortality from the 1969 Santa Barbara oil spill was not well investigated. However, coastal areas around Anacapa and Santa Cruz Islands were oiled in the January-May period when murrelets attend nocturnal at-sea congregations beside colonies. Some or many murrelets from these colonies probably were killed (Carter et al. 2000).

The Department considers it probable that another spill will occur in the Channel Islands area, given the volume of vessel traffic, military activities, and the existence of numerous oil platforms (Figure 19). Murrelets forage over a wide area in the Channel Islands, and have been documented to travel mean distances of 62 -111 km (39 – 69 miles) from Santa Barbara Island during the breeding season (Figure 20; Whitworth et al. 2000). When the existing oil extraction facilities and shipping lanes are compared with known murrelet foraging locations, the potential for severe impact to murrelets from a large spill event is evident (Figure 21). The natural oil seeps in the Southern California Bight are not considered a severe threat to the murrelets because most of the seeps occur nearshore, while the murrelets are most commonly found further offshore, nearer the Channel Islands (Figure 21).

In addition to threats from an acute large oil spill, Xantus's Murrelets are also at risk from chronic oil pollution associated with illegal discharges from tank washings and oily bilge waste. Such discharges typically occur in shipping lanes or farther from shore, which increases the probability of harm to Xantus's Murrelets (Hampton et al. 2003).

Because oil spills can occur due to accidents, it is difficult to predict when the next spill event might occur. The Department believes that oil pollution constitutes a potential threat to Xantus's Murrelets. The support for this position is further outlined below.

Factors Affecting the Ability to Document Mortality of Xantus's Murrelets During Oil Spill Events

There are two main reasons why Xantus's Murrelet carcasses have a low likelihood of being documented during a spill event:

1) Offshore habitat use by murrelets, where less oil spill response occurred, at least in the past.

2) At-sea carcass loss due to sinking or scavenging following exposure far offshore.

Additionally, recent studies by the Department's Office of Spill Prevention and Response have confirmed that small-bodied bird carcasses, such as murrelets, are hard to recover, relative to larger carcasses, along coastal beaches due to a fairly rapid scavenging response by predators. It is also recognized that searchers have greater difficulty finding smaller (vs. larger) carcasses, even on beaches. The conclusion from the Department's scavenging study is supported by the lack of beached murrelets ever collected by the Beach Watch Program, from 1993-1999 (pg. 12 in the petition). If a spill were to occur in the Channel Islands area today, the Department's response would be much more intensive than it was prior to formation of the Office of Spill Prevention and Response.

Background on Seabirds and Oil Development in the Southern California Bight

The 1969 Santa Barbara oil spill event ushered in the beginning of studies on the effects of oil on seabirds. In the mid 1970s, the first major biological investigation into Channel Island seabird populations and ecology was initiated (Hunt et al. 1979). That study was funded specifically to analyze the potential impacts from oil development and oiling of seabirds, because the danger to seabirds was recognized.

A 1980 summary of potential oil spill impacts to murrelets noted: *"Because Xantus' Murrelets, like other alcids, spend a lot of time on the water and dive for food, they are vulnerable to oil spills. Location of spills in the California Bight during the breeding season would be the most critical, ..."* (Sowls et al. 1980).

Oil Pollution Summary

The potential for oil spill impacts to murrelets is striking (Figure 21), and was noted in a definitive paper on the subject (Carter et al. 2000). Additionally, as noted earlier, murrelets are at risk from chronic oiling in the marine environment (Hampton et al. 2003). If a spill event occurred during the murrelet breeding season, the result could cause extirpation or extinction, depending on the size of the spill. Two recent spills in California have caused harm to endangered Marbled Murrelets in northern California; both of those spill events were accidents. Xantus's Murrelets were likely affected by the American Trader oil spill that occurred in southern California in 1990, even though no carcasses were recovered. Accordingly, part of the restoration plan for that spill includes the rat eradication program at Anacapa Island to benefit Xantus's Murrelets and other seabirds (American Trader Trustee Council 2001).

One potential mitigating factor relative to oil spill risk is that double-hulled tankers are currently being phased in. There are other various preventive measures that have been initiated in the recent past (*e.g.*, various technologies to reduce the amount of oil spilled at a platform or from a pipeline, and the evolution of segregated ballast tanks to reduce the amount of chronic oil discharge).

Native Predators

<u>*Barn Owl*</u>

Barn owls (*Tyto alba*) are well documented as predators on adult Xantus's Murrelets (Murray et al. 1983, Drost and Lewis 1995, Wolf et al. 2000), though their usual prey is small mammals and rats (Bent 1961:145-148, Marti 1992). An intensive six-year (1982-1987) study by Charles Drost on Santa Barbara Island provides a framework for evaluating the relationship between owls, murrelets, and deer mice (Drost *in* Drost and Lewis 1995). For additional discussion of the owl/deer mice relationship, see the Deer Mice section, below.

High numbers of owls (21-33 individuals) have been counted on Santa Barbara Island in some years. Even the low counts of 4-7 owls seem to represent an unusual situation for such a small island. Owl densities are not known to be this high based on published literature (Marti 1992). In southwestern Scotland, Barn Owls reached a density of 5.1 pairs per 10 square kilometers, during years when the prey base was abundant (Taylor et al. *in* Marti 1992). That density converts to only 1.3 Barn Owl pairs for Santa Barbara Island (the island is approximately 1 square mile in size, or 2.6 square kilometers). If the owls are not all nesting on Santa Barbara Island, they are probably coming from the mainland, or other islands, to forage on the abundant deer mice and other prey, including murrelets. Barn Owls are known to fly and forage over water, though few studies have investigated their maximum foraging distance (Mueller 1979, Marti 1992, Lehman 1994). In New Jersey, radio marked adult owls traveled a maximum distance of 3.5 miles (5.6km) from roost to hunting areas (Hegdal and Blaskiewicz *in* Marti 1992). Immature owls can disperse up to 1,180 miles (1900km) from the site where they were born (Soucy *in* Marti 1992). Santa Barbara Island is located 61 km (38 miles) from the mainland coast.

As described later in the Artificial Light Pollution section of this report, owls may be attracted to lights for foraging. A statement contained in Wolf et al. (2000) documents owl attraction to lights on Santa Barbara Island: "*Barn Owls, in particular, are attracted to light sources at night*" (personal observation, S. Wolf and J. Roth). However, details of these observations were not provided in the report.

In another example, owls may have utilized artificial lights when foraging at Lihue Airport on the island of Kauai, Hawaii. Studies at the Lihue Airport on Barn Owls and other birds were initiated in order to alleviate bird strikes (collisions) with aircraft.

An unusually high number of Barn Owls were present at the airfield from March to April 1992. Four owls were normally observed, but as many as 19 were noted on one survey. A rodent survey was conducted at the airfield that showed a virtual absence of rodents compared to adjacent fields. The owls (which were introduced onto the island by humans) were shot to avoid additional collisions with aircraft, and stomach analyses revealed crickets (*Gryllida* sp.) in the diet, which is unusual for Barn Owls (Bent 1961:145-148, Marti 1992, U.S. Dept. of Agriculture 1996). At this same airport, the threatened Newell's Shearwater (*Puffinus auricularis newelli*) is known to be attracted to the airport lights, and juveniles must be retrieved when they become disoriented by the lights and land on the airfield (U.S. Dept. of Agriculture 1996).

However, raptor expert P. Bloom (pers. comm.) thought that Barn Owls were probably not attracted to lights per se, based on his many years of field experience with Barn Owls in particular, and Marti (1992) makes no mention of it. In order to better understand if Barn Owls will take advantage of artificial light sources, P. Bloom recommended further study, including studies on Barn Owl predation effects and densities on Santa Barbara Island. He also admitted he was unfamiliar with Barn Owl ecology in offshore environments. P. Bloom also noted that if Peregrine Falcons were present, they would prey on Barn Owls and perhaps help reduce their numbers. Barn Owls are primarily nocturnal, while falcons are diurnal, but both species can be active at dawn and dusk. A California database on peregrine food habits has never documented Barn Owls as a prey item (J. Linthicum, pers. comm.). Therefore, falcon presence may not significantly affect owl numbers.

Though Barn Owls are primarily nocturnal, they do not necessarily avoid light, as indicated by a nest site that was located in a steel range light on a tower in the Savannah River in Georgia. A picture of this nest site is contained in Bent (1961: Plate 27); the tower was surrounded by water. "*The nest was in a steel box about 2 feet square, with part of the west side open to the sun, under the light, and was liberally carpeted with pellets. The keeper of the light says the owl has nested there for about four years*" (I.R. Tomkins *in* Bent 1961:142).

Barn owls are also known for taking excess prey and not consuming it. The excess prey can number from 30-50 (Marti 1992), and as high as 189 individual prey items (Wallace *in* Marti 1992). The excess prey is stored in the nest site during incubation and early brooding of young owls. There is no conclusive evidence that food storing occurs outside the breeding season, but captive individuals often hide excess uneaten prey (Bunn et al. *in* Marti 1992). An example of prey storage for a seabird species taken by owls provides the following details: "*...I visited Castle Rock, a large rock which lies off Crescent City, California, and which supports an extensive rookery of sea birds. There was an old cabin on the Island which had fallen partly to ruin. Under a built-in wooden bedstead was the nest of a Barn Owl ...The area covered by the bed was three inches deep with the feathers, wings and bodies of Beal Leach Petrels...* [sic] [Leach's Storm-Petrels]...*These little birds were evidently so easily* *caught that there were numbers of bodies with only the heads removed, and I collected for study three specimens with hardly a feather misplaced. A good number of the bodies of the petrels were rotting and inhabited by fly larvae…*" (Bonnot 1928).

Drost and Lewis (1995) thought barn owl predation did not have a significant effect on murrelets. They stated: "Even though Barn Owl predation on murrelets at Santa Barbara Island may be high, there is no evident effect on long-term population size; numbers in years following heavy predation are not significantly different from numbers in years following light predation" (Drost and Lewis 1995).

However, this statement seems to contradict other statements in Drost and Lewis (1995), for example:

- "*Barn owls and Peregrine Falcons are the most important native predators on [murrelet] adults at breeding colonies.*"
- "*Heavy predation by Barn Owls has been noted on Santa Barbara Island.*"
- "*In heavy predation years (when mice are rare), owls have killed over 130 adult murrelets, representing nearly 10% of the nesting population on the island.*"

In summary, some of the conclusions of Drost and Lewis (1995) may no longer be valid, based on more recent work indicating murrelet population decline (Sydeman et al. 1998, Carter et al. 2000, Wolf et al. 2000, NPS unpublished data, 2002). Population modeling by Sydeman et al. (1998) indicated owl predation might be sufficient to cause a decline in the Santa Barbara Island population of murrelets.

<u>*Deer Mice*</u>

Native deer mice have been documented as preying heavily on Xantus's Murrelet eggs, and they are also known to eat unattended chicks (Murray et al. 1983, Drost and Lewis 1995). An intensive study by Murray et al. (1983) on Santa Barbara Island documented that 44% of murrelet eggs laid were consumed by mice.

National Park Service biologists annually monitor the murrelet nest sites at the two nest study plots on Santa Barbara Island (Cat Canyon, Figure 8), and Nature Trail, Figure 9) as described in the Population Trend section of this report. Biologists examine the eggs for evidence of mouse predation, and a protocol has been set up for collecting this data since the 1980s. As was noted in the Population Trend section, occupancy rates have been declining at these two study sites from 1985-2002 (Figures 10a and 10b).

The Department found evidence that the deer mouse situation on Santa Barbara Island is highly unusual (Drost and Fellers 1991), and may indeed cause predation rates on murrelets to be higher than would normally be expected. As noted by Sydeman et al. (1998), this level of predation appears too high to sustain the murrelet population on Santa Barbara Island. This is based on inferred population parameters for the Xantus's Murrelet, from the closely related Ancient Murrelet. The Department believes that serious consideration of potential control of deer mice may be necessary to conserve the Xantus's Murrelet. A more recent study on the mice by the NPS (Schwemm and Coonan 2001) confirms the results of the Drost and Fellers (1991) work. The details of the mouse population cycles on Santa Barbara Island are summarized below.

The deer mouse population followed a pattern of multi-annual increase to high numbers, followed by a sharp decline to much lower numbers, with peaks separated by three of four years (Drost and Fellers 1991). This type of cycle is highly uncharacteristic for deer mice, based on most published literature. Density of deer mice very rarely reaches the levels recorded at Santa Barbara Island; information presented in Drost and Fellers (1991) indicates the deer mice numbers on Santa Barbara Island are the highest recorded from published studies in North America (an order of magnitude greater than typical deer mouse densities). They found no evidence that deer mice are cyclic and in such high densities on other island situations in North America. In fact, they found no indication that island isolation is characteristically associated with cyclic population behavior. A review by Tait and Krebs *in* Drost and Fellers (1991), suggested at least a five-fold difference between peak and low numbers is characteristic of cycles, and the difference between highs and lows on Santa Barbara Island is over 25 times.

The two most plausible reasons for the high numbers of deer mice on Santa Barbara Island are the relative lack of competition and the depauperate assemblage of predators on the island (Drost and Fellers 1991). Because the deer mice occupy the shrubby habitat in higher densities than the more open grasslands, this puts the deer mice right where the murrelets nest, in the shrubby habitat. The shrubby habitat is utilized by the murrelets for cover from predators and thermal regulation. The mice seek this same cover, also for protection from the same primary predator, the barn owl.

The resident barn owl population has shown a pattern of increase, peak, and decline which tracks the population pattern of deer mice. Peak numbers of up to 25 owls have lagged slightly behind corresponding peaks in the mouse population. After deer mouse declines, barn owl numbers decreased to lows of seven (1984-85) and four (winter 1988) individuals (Drost and Fellers 1991).

A complex interaction of rainfall patterns and associated vegetation response leads to population changes in deer mice and barn owls on Santa Barbara Island (Drost and Fellers 1991). Whether such highly unusual cycles existed prior to human induced changes in vegetation on the island remains an important, unanswered question.

Peregrine Falcon

The petition raised a concern that increased predation pressure by peregrines on Xantus's Murrelets may occur given the recent reappearance of breeding peregrines on Santa Barbara Island, and other Channel Islands. This concern is probably valid, because peregrines are known predators of Xantus's Murrelets (Howell 1910, Bent 1961, Huey *in* Kiff 1980; B.J. Walton, pers. comm., in the petition).

At this time, the Department found no information to indicate that Peregrine Falcons are an imminent or significant threat to murrelets. However, the potential for peregrines to impact murrelets is supported by the scientific literature. Because of the potential for peregrines to negatively affect murrelet populations, some elements of their biology are described below, including history of their abundance in the Channel Islands. Peregrine Falcon predation is potentially an emerging threat.

Peregrines are known to prey chiefly on birds, and there are reports of at least 22 species of birds being taken on the Channel Islands and Los Coronados Islands (Kiff 1980). Bent (1961:53-54) noted a very long list of bird prey items, including murrelets; it was also noted that "*...on the seacoast and islands, these hawks live almost exclusively on the smaller sea birds.*" A peregrine nest site examined on Los Coronados Islands in 1924 contained 12 bird species, and included at least 42 pairs of wings of Xantus's Murrelets (Huey *in* Kiff 1980:664). An extreme example of peregrine predation pressure on Ancient Murrelets is noted from British Columbia. Researchers stated that, in a year, a family of peregrines (two adults and four young) will kill about 1,000 Ancient Murrelets (Nelson and Myres *in* Kiff 1980).

The following discussion on peregrine extirpation is drawn from a comprehensive summary of historical changes in raptor populations in the Channel Islands, including the Los Coronados Islands (Kiff 1980). Historically, peregrine falcons were resident and breeding on all the Channel Islands. Up until the 1940s, virtually all authorities considered the peregrine to be at least fairly common on the Channel Islands, and at least 20 pairs of peregrines are thought to have been resident. But, in the two decades following 1945, a catastrophic decline occurred in California peregrine populations. Available information indicates the peregrine was extirpated from the Channel Islands by 1955. It is now acknowledged that the pesticide DDT was the main reason for this decline. DDT was first used widely in the United States in 1947. The principal metabolites of DDT are referred to generically as DDE, known for causing eggshell thinning in populations of bird-eating and fish-eating wild birds. Eggshell thinning led to reproductive failure for the peregrine, and affected many other species as well (Kiff 1980).

Because peregrines were extirpated from the Channel Islands as breeders by 1955, and only recently reappeared in 1996 at Santa Barbara Island, Xantus's Murrelet populations have not been under intensive predation pressure from the falcons for approximately 41 years. This period of peregrine absence is likely longer than the life span of a Xantus's Murrelet. While murrelets have instinctive predator avoidance behaviors, such behaviors are naturally fine-tuned in response to exposure and interaction with predators. Thus, a period of adjustment is likely underway at present, as murrelets adapt to the return of a natural predator.

Seabird researchers in Washington State have documented both positive and negative effects of the peregrine falcon population recovery. Studies on seabirds that breed on Tatoosh Island have indicated that falcons prey heavily on some species (and may cause population declines), but falcons may help other seabird populations to increase by controlling northwestern crows (*Corvus caurinus*). These researchers state that caution is in order when undertaking programs to augment peregrine populations, because many seabirds are already under a variety of threats (oil spills, human disturbance, El Niño events) and thus may not be able to withstand falcon predation (Paine et al. 1990).

Peregrines are also documented as a predator of two endangered species of seabirds that nest in California, the California Least Tern (*Sterna antillarum brownii*) (Keane 2001), and the Marbled Murrelet (USFWS 1997:55, Burkett et al. 1998). Once prey species are reduced in number from historic levels, and subject to numerous other threats (as is the case with the Least Tern and Marbled Murrelet), then predation effects can serve to exacerbate population declines (Fancher 1992, USFWS 1997:54-55, Keane 2001).

Artificial Light Pollution

Artificial light pollution is a threat to the survival of the Xantus's Murrelet, particularly at breeding sites. Xantus's Murrelets are nocturnal in their activities at colonies. Nocturnal seabirds are active at night (main theory is to avoid predation), and as such are adapted to night-time conditions. No studies have been done to try and quantify the extent of the problem, but the impacts of light attraction may be of a chronic and serious nature, as there are many sources of artificial lighting in the waters around and on the islands used by this murrelet.

This species is attracted to light and in particular to lighted vessels (Howell 1910, Jehl and Bond 1975, Hunt et al. 1979, Whitworth et al. 1997). Small amounts of vessel lighting have been documented to cause parent-chick separation in the Channel Islands (B. Keitt, P. Kelly, G. McChesney, and M. Naughton, pers. comm.), though temporary separation at night may not result in mortality.

Other sources of lighting, including flashlights and lanterns in breeding colonies can be a problem, particularly for chick disorientation. As early as 1910, Howell noted: [Xantus's] "Murrelets are also attracted by light, as is the case with so many of the nocturnal sea-birds, and I have had them enter my tent thru the front flap and under the sides at night when my lantern was lighted." Chicks will die if separated from their parents after departing nesting sites as they are dependent on their parents for an extended period of time at sea (Gaston and Jones 1998).

The Pacific Seabird Group documented their concern over vessel lights as an attractant to murrelets in a letter dated August 15, 1994 (Appendix E). Item nine on an attachment to that letter reads: "*Investigate and implement policies to control unnecessary use of bright deck lights by boats anchored at Santa Barbara Island.*" The current state of the science on seabirds and artificial lights is discussed below.

Artificial night-lighting has been shown to cause disorientation in birds of many different species and has been documented to result in birds becoming exhausted due to continual attraction and fluttering near lights, or birds colliding with lighted structures, resulting in injury or immediate death (Bretherton 1902, Verheijen 1958, Herbert 1970, Avise and Crawford 1981, Fedun 1995, Bower 2000). Verheijen (1958) also noted that "birds can be captured with light." Since that time, the scientific community has actually used artificial lights as a technique for capturing birds for research purposes. This technique to disorient birds, allowing easy capture, has been used for a variety of species and reported in the literature, including several species of waterfowl (Cummings and Hewitt 1964, Bishop and Barratt 1969), Trumpeter Swans (*Cygnus buccinator*) (Drewien et al. 1999), Common Eiders (*Somateria mollissima*, a sea duck) (Snow et al. 1990), Double-crested Cormorants (*Phalacrocorax auritus*) (King et al. 1994), Marbled Murrelets (Burkett et al. 1998; and others), and Leach's and Fork-tailed Storm-petrels (*O. furcata*) (Williams et al. 2000). In the Channel Islands, this technique has been used to capture Xantus's Murrelets for radio telemetry studies (Whitworth et al. 1997, Carter et al. 2000).

Seabird attraction to man-made lights, including lighthouses and ship lights, has been noted worldwide, particularly among the Alcidae, as well as among the Procellariiformes (which include albatrosses, petrels, shearwaters, storm-petrels and diving-petrels) (Howell 1910, McLellan 1926, Miller 1936, Verheijen 1958, DeLong 1967, DeLong 1968a, DeLong 1968b, DeLong and Brownell 1968, Manuwal 1974, Jehl and Bond 1975, Byrd et al. 1978, Dick and Donaldson 1978, Hunt et al. 1979, Reed et al. 1985, Reed 1987, Telfer et al. 1987, Cherel et al. 1994, Bertram 1995, Carter et al. 1996, Cherel et al.1996, Whitworth et al. 1997, Chardine and Mendenhall 1998, Ryan and Watkins 1999, Carter et al. 2000, Weimerskirch et al. 2000). Fog or low cloud cover has been noted to make the attraction problem worse.

The attraction of seabirds to lights of commercial fishing vessels has been noted in observer programs for longline fisheries (Cherel et al.1994, Cherel et al. 1996, Ryan and Watkins 1999, Weimerskirch et al. 2000). Mitigation measures for reducing seabird bycatch in the longline fisheries from several countries acknowledge that birds are attracted to lights and require minimal vessel light use at night for this reason. For example, the Commission for the Conservation of Antarctic Marine Living Resources (the organization that regulates Antarctic fisheries) implemented Conservation Measure 29/XIX, which includes the following measure: "During longline fishing at night, only the minimum ship lights necessary for safety shall be used" to decrease incidental seabird mortality (From the Conservation Measures and Resolutions adopted at CCAMLR-XIX, available on the web site, www.ccamlr@ccamlr.org).

For rare or declining seabirds, artificial night-lighting close to breeding sites can significantly contribute to further decline. This type of impact has been particularly well-documented for two nocturnal seabird species in Hawaii, the threatened Newell's Shearwater and the endangered Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*) (Byrd et al. 1978, Simons 1984, Reed et al. 1985, Reed 1987, Ainley et al. 1997, Telfer et al. 1987, Podolsky et al. 1998). Fatal light attraction to fishing vessels has been documented as contributing to the decline of Ancient Murrelets on Langara Island, British Columbia (Bertram 1995).

In addition to light attraction and disorientation, the breeding activities of nocturnally active seabirds can be altered by lighted conditions. Studies have shown that nocturnal seabird species display highly reduced activity levels on moonlit nights when they are apparently more susceptible to predation, and that levels of colony attendance are inversely proportional to increasing light levels (Manuwal 1974, Storey and Grimmer 1986, Watanuki 1986, Jones et al. 1990, Klomp and Furness 1992, Keitt 2003, in review). These studies also show that nocturnal species do not return to colonies, and to their nests, until the sun and moon set; thus on full moon nights, the amount of time of total darkness and access to their nests for incubation shift changes and for departure of chicks to sea is very limited. Therefore, it is reasonable to expect that successive nights of high artificial light levels on and around breeding colonies would disrupt the normal nesting activities of murrelets, which could result in nest abandonment, increased mortality of eggs and/or chicks, and increased predation rates of adults that do return during lighted conditions.

While all types of island lights and lighted vessel activity may affect Xantus's Murrelets, the largest potential for impact during the breeding season is from the market squid fishery at the Channel Islands. This is due to the fishery's current reliance on the use of light boats to attract squid for night-time fishing. These light boats use higher wattages of light than other types of boats in the area (average wattage of 22,500 watts; legal maximum since May 2000 is 30,000 watts), thus if they are close to breeding sites of murrelets during the breeding season, the potential does exist for interactions with the light boats or altered behavior in breeding colonies. Total squid landings and number of vessels participating in the fishery in southern California has increased since the 1970s, and squid fishing occurred off Santa Barbara Island during the murrelet breeding season in 1999 (Figure 22).

The petition cites data collected by the Channel Islands National Park on Santa Barbara Island that higher mortality rates of Xantus's Murrelets by nocturnal predators occurred in 1999, which correlates with squid fishing near the colonies. The petition states that murrelet kills by Western Gulls (*Larus occidentalis*), which are normally a diurnal species, were noted in 1999. Western Gulls are documented to prey on Xantus's Murrelets (Oades 1974, Hunt et al. 1979, Murray et al. 1983). Park staff also noted that Western Gulls were more active at night when squid lights were on in 1999. Other studies have shown that gull activity and predation does increase with lighted conditions (Nocera and Kress 1996, Keitt 2003, in review).

An increased mortality rate of murrelets due to predation by Barn Owls was also recorded (Channel Island National Park, unpublished data). Data on Barn Owl predation for Santa Barbara Island show the highest recorded murrelet mortality rate occurred in 1999 (Figure 23), however, 30 owls were estimated to be present on the island that year, which is higher than other years when owl surveys were conducted. Deer mice numbers were exceptionally low in 1999 as part of the low phase of their cycle (Schwemm and Coonan 2001). Thus it is difficult to determine if increased owl predation rates in 1999 correlates with lighted conditions or unusually high owl presence. More murrelets may have been killed because there were fewer mice for the owls to prey on. But, as noted in the petition, high nest abandonment was recorded in the murrelet study plot closest to the most intense fishing activity at Santa Barbara Island and researchers did observe owl attraction to lighted areas (Wolf et al. 2000).

The Commission adopted measures effective 31 May 2000 that required light shields and a maximum light wattage of 30,000 watts on market squid fishing vessels in an effort to reduce light pollution in the Channel Islands. Since that time, the Department has not collected any data from the market squid fishery as to its potential impacts to Xantus's Murrelets or other seabirds, as there has been no observer program for the fishery, and no studies have been conducted on the effectiveness of the light shield and wattage limitation regulations. Likewise, with respect to the order by the Commission authorizing limited incidental take during the candidacy period (Appendix H), the Department did not have sufficient staff to monitor the situation during 2003. The Department received one complaint of lighted vessels working on the south side of East Anacapa Island during the breeding season (April 2003). Researchers noted that the area the lighted vessels were in has the densest at-sea congregation of murrelets at Anacapa Island (D. Whitworth, pers. comm.). Also, the Department's draft Market Squid Fishery Management Plan examines several seabird closure options in the Channel Islands that would benefit murrelets. A decision on the preferred option for the plan is pending until it is scheduled at a Commission meeting and considered.

Based on the above, artificial night-lighting, particularly close to the breeding sites of Xantus's Murrelets in the Channel Islands, has a reasonable potential to cause the following impacts on this species:

- Disruption of courtship activities due to disorientation and distraction in nearshore waters.

- Colony-site and individual nest abandonment.

- Increased predation rates of breeding adults as they leave/return to nests, and of chicks has they depart the nests for the sea by increasing the visual abilities and activity levels of predators.

- Decreased nest attendance, and as a result decreased egg incubation and possible egg/chick mortality due to reluctance of parents to return to the colony under "moonlight" types of conditions (predator avoidance).

- Chick-adult separation at fledging state due to disorientation.

- Direct collision of birds with vessels resulting in injury or direct mortality. In addition, if breeding individuals are affected, this will result in egg/chick mortality due to nest abandonment.

Minor Threats

Human Disturbance at colonies

Interagency cooperation is necessary in order to protect murrelets and other seabirds that nest in sea caves and offshore rocks. The Department is already working with NPS and others on educational materials as part of the Anacapa Island rat eradication project. In order to minimize disturbance to nesting murrelets, it would be beneficial to develop educational materials to discourage park visitors from straying off-trail on Santa Barbara Island. The Department, NPS, and other interested parties should continue to work together to design management solutions for protection of murrelets. Measures that could be used to assure nest sites are protected from direct and indirect human disturbance include increased signs on the islands, visitor orientation lectures, signs on buoys, educational leaflets, and press releases.

Oceanographic and prey changes

Very few studies have been conducted on murrelet food habits. Limited diet data were obtained from stomach analysis of 22 murrelets collected at-sea near Santa Barbara Island during the 1977 breeding season (Hunt et al. 1979). Larval Northern Anchovies *(Engraulis mordax)* were the predominant species in the samples, comprising nearly half of the total volume of samples analyzed. Larval Pacific Sauries (*Cololabis saira*) and rockfish (*Sebastes* sp.) were also taken. Elsewhere, unidentified crustaceans (known as zooplankton) (Howell 1910), and sand lance (*Ammodytes* sp.)

have been noted as prey items (Los Angeles Co. Museum # 105851 *in* Drost and Lewis 1995).

More recently, results from 10 murrelets collected at-sea in May 2002 between Anacapa and Santa Cruz Islands revealed subadult and adult Northern Anchovies (n=2 stomachs), juvenile Bluefin Driftfish (*Psenes pellucidus*) or Medusafish (*Icichthys lockingtoni*) (n = 2 stomachs), and euphausiids (*Thysanoessa spinifera*) (n =3 stomachs) (Hamilton et al. 2003).

Xantus's Murrelets forage widely in the Southern California Bight (Figure 20), and prey on numerous species of zooplankton and fish. However, more studies on Xantus's Murrelet food habits are needed. For comparison, studies on other alcids are helpful: 1) Marbled Murrelets appear to be opportunistic feeders with a high capability for "prey-switching", based on prey availability (reviewed in Burkett 1995); 2) Ancient Murrelets seem to rely more on zooplankton prey (Gaston and Jones 1998); and 3) Craveri's Murrelets eat many species of non-larval fish, and squid (DeWeese and Anderson *in* Gaston and Jones 1998). Thus, in general, Xantus's Murrelets are probably capable of foraging opportunistically on a variety of both small fish and zooplankton prey (Carter et al. 2000, Hamilton et al. 2003).

Cassin's Auklets feed on zooplankton, and the auklet population on Southeast Farallon Island has shown a decline attributed to decreases in food availability and shifts in prey resources (Pyle 2001). The decline in Cassin's Auklets at the Farallon Islands may also be related to high gull predation (Carter et al. 1992). Lately, the auklet population appears to be on the increase at the Farallons coincident with a recent increase in zooplankton occurrence near the Farallons (W. Sydeman, pers. comm.). These changes indicate the complex relationships that exist between seabirds, their predators and prey, and the physical environment.

Xantus's Murrelet distribution at sea may have changed between the mid 1970s and the mid 1990s (Whitworth et al. 2000), although it is unclear if this was related to prey availability. There is considerable natural variability in interannual abundance and species composition of zooplankton in the Southern California Bight. For example, total zooplankton (including salps and jellyfish) in southern California waters declined by 80 percent between the 1950s and the early 1990s (Roemmich and McGowan 1995), but a major component in the overall decline was reductions in salps and jellyfish. Zooplankton species that may comprise prey items for Xantus's Murrelet such as icthyoplankton, euphausiids, and copepods showed comparatively little change in combined abundance during the same period. However, high variation in abundance of the euphausiid *T. spinifera*, a known murrelet prey item, makes any trend very difficult to discern; the surface aggregating behavior of euphausiids also makes sampling and determination of trend difficult (Brinton and Townsend 2003).

In southern California, larval northern anchovies appear to be undergoing population decline (Figure 24), but Xantus's Murrelets may be able to "prey-switch" from northern anchovies to Pacific Sardines (*Sardinops sagax*). Although the recent recovery of Pacific sardine biomass has not reached the level of the 1930s (Conser et al. 2002), the magnitude of the sardine population increase since 1983 was greater than the corresponding decline in northern anchovy (Jacobson et al. 1995), which may mitigate the loss of anchovy in murrelet diet.

Declines in fish stocks are likely driven by a combination of factors including fishing pressure, natural long and short term oceanic cycles, and perhaps even global warming. The frequency of warm events in the marine environment has increased since 1977 off the West Coast of North America (McGowan et al. 1998). Seabird reproduction is known to be affected by prey availability from studies worldwide. Thus, this aspect of murrelet ecology needs further investigation.

Military Operations/San Clemente Island

San Clemente Island is used as a Department of Defense U.S. Navy (US Navy) training facility. A small breeding population of 10-50 pairs of Xantus's Murrelets is known from the island (Figure 16; Carter et al. 1992, H.R. Carter, unpubl. data, May 2002). Murrelet eggshell fragments have also been documented on an offshore rock near Seal Cove (Drost and Lewis 1995, H.R. Carter, unpubl. data).

Sheep ranching occurred on the island between 1850 -1934. The US Navy gained control of the island in 1934 and canceled the grazing leases. Twenty-two new facilities were constructed on the island from 1935 - 1936. During World War II, the island was used for bombing exercises. From 1950 -1951, the first underwater test ranges were developed. Currently, 500 personnel are stationed on the island, but numbers can swell to 1,000 periodically. The US Navy conducts some operations at night around the island, and Seal Cove is sometimes used as an anchorage. In the past, sea stacks and rocky shores have been used as military targets.

The US Navy recently completed their Integrated Natural Resources Management Plan (INRMP) for San Clemente Island in May 2002. The INRMP will provide a framework to manage natural resources on the island for the next five years, while still preserving the military mission at the installation. Xantus's Murrelets were specifically identified in the INRMP and some measures to protect the murrelets and other species were described, for example: 1) Establish a standardized monitoring program for birds to track seabird occurrence and trends; 2) Focus surveys on sea stacks around the island to determine use by seabirds; 3) Focus surveys on listed species and species of concern (including the Xantus's Murrelet); 4) Develop a standard format and database to collect and maintain records of bird observations on the island; 5) Identify and limit disturbance to sea stacks and rocky shores potentially used by seabirds; 6) Do not use sea stacks or known colony locations as military targets; 7) Avoid high-intensity artificial light near murrelet breeding sites; 8) Survey shorelines for use by cats and rats and continue efforts to remove feral predators from the island; and 9) Develop an all-Island approach to rat and cat management.

The petition noted that military activities in the Sea Test Range have increased over the last two decades (part of the Sea Test Range is depicted in Figure 3 in the petition). It also pointed out that studies of radio-marked murrelets from Santa Barbara Island showed high overlap between murrelet foraging distribution and areas of extensive Sea Test Range use (Carter et al. 2000, Whitworth et al. 2000). However, the petition listed military operations as a minor threat, and noted that the extent of impacts to murrelets is unknown. The Department concurs with this assessment, and will continue to work with the US Navy to further the conservation of the murrelet. The INRMP described above should prove useful to the enhancement of murrelet nesting opportunities on San Clemente Island.

Bycatch in fisheries

The petition lists bycatch in commercial fisheries, particularly in gill net fisheries, as a minor threat to Xantus's Murrelets. The Department is not aware of any documented occurrences of Xantus's Murrelet bycatch in fisheries other than the one account cited in the petition (off British Columbia, Carter et al. 2000). Whether mortality of Xantus's Murrelets in fishery bycatch is occurring and/or contributing to the decline of the species is difficult to assess given the lack of data.

Alcids have been reported as bycatch in commercial fisheries, particularly in gill net fisheries. While the diving depth of the Xantus's Murrelet is unknown, all alcid species pursue their prey underwater, using their wings for swimming, which makes them vulnerable to entrapment in fishing nets (Piatt and Nettleship 1987). From our review of the available information, it appears bycatch may be a threat to the murrelet. The basis for this conclusion is discussed below.

Closely related alcid species [including the Marbled Murrelet, Ancient Murrelet, and Japanese Murrelet, which are similar in size to a Xantus's Murrelet] have been recorded as bycatch in gill net fisheries for salmon (*Oncorhynchus* spp.), flying squid (*Ommastrephes bartrami*), white croaker (*Genyonemus lineatus*), and Pacific herring (*Clupea pallasi*), along the west coast of the United States (including California), and including: Alaska, British Columbia, the Bering Sea, Japan, Taiwan, and Korea (Ainley et al. 1981, Carter and Sealy 1984, Carter and Erickson 1988, DeGange and Day 1991, Johnson et al. 1991, Ogi et al. 1991, DeGange et al. 1993, Piatt and Gould 1994, Bertram 1995, Carter et al. 1995, Carter et al. 2002). The mortality of Ancient Murrelets in salmon gill nets close to the breeding colony on Langara Island, British Columbia has been suggested as a significant contribution to the decline of this species on that island (Bertram 1995). Gill net mesh sizes used in these fisheries ranged from 2.75 inches to 9.0 inches.

The petition states that the white seabass (*Atractoscion nobilis*) set and drift gill net fishery may capture Xantus's Murrelets. The Department currently has little data on bycatch from this fishery as observations have not occurred for some time, since the fishery moved offshore and closer to the Channel Islands. However, this past summer (2003) the National Oceanic and Atmospheric Administration's Fisheries (NOAA Fisheries) observer program initiated observations in the white sea bass fishery (D. Petersen, pers. comm.). Twenty white sea bass sets (set and drift) were observed in southern California (June/July 2003) and no birds were entangled. NOAA Fisheries will continue to place observers on vessels using small mesh drift and set gill nets (D. Petersen, pers. comm.). The Department has not yet been fully briefed on the extent of this program, and the specific geographic areas where the observers are working.

The White Seabass Fishery Management Plan (2002) lists determining accurate estimates of bycatch as one of its research needs goals (Final Plan, chapter 7, page 12). The plan acknowledges that "it is necessary to investigate these interactions, particularly with regard to pinnipeds, birds, and sea turtles through an at-sea observer program." Around the Channel Islands where the murrelet breeds, white sea bass fishing effort has declined over the past ten years (CDFG, unpublished data) and the fishery is closed during part of the murrelet's breeding season, from 15 March to 15 June. But the main fishing season occurs from mid-June through July (CDFG, unpublished data), which coincides with murrelets foraging out at-sea with their dependent chicks. Until the observer program has been in place for a few years, it will be difficult to assess if take of Xantus's Murrelet is occurring in this fishery; but the potential exists given that the mesh size of 6-7 inches used in the fishery can entangle a murrelet-size bird, and that the fishery is concentrated in the Southern California Bight, where the species forages through most months of the year.

Other set and drift gill net fisheries currently operating in California which could potentially take a murrelet-size bird include white croaker (mesh size 2.75 inch), California barracuda (*Sphyraena argentea*) (3.5 inch), rockfish (*Sebastes* spp.) (4.5 inch), bottom shark (6 to 8.5 inch), soupfin shark (*Galeorhinus galeus*) (6.5 to 11 inch), and California halibut (*Paralichthys californicus*) (8.5 inch). In addition, white sea bass drift gill nets (small mesh size ranging from 6 to 7 inch) have historically been used to fish at the surface for yellowtail (*Seriola lalandi*), and recently for certain tuna species (*Thunnus* spp.) along central and southern California (B. Read, Department of Fish and Game, and Campbell, Forney, and Smith, NOAA Fisheries, pers. comm.).

Radio telemetry studies of Xantus's Murrelets captured at Santa Barbara Island indicate that this species is a long-distance forager while breeding, traveling a mean distance of 111 km (68 miles) from the island (Whitworth et al. 2000). During the non-breeding season, this species can be found up to, and occasionally beyond 200 km (124 miles) offshore along the entire California Coast and elsewhere in its range (Spear et al. 2003). Therefore, Xantus's Murrelets are found in waters where gill net fishing occurs.

Carter et al. (2000) suggest that it is unlikely that large numbers of Xantus's Murrelets are killed in gill nets. This may be partly due to the observation that murrelets do not aggregate in large numbers for foraging and do not appear to forage when staging in the evenings in large numbers near breeding sites. In addition, incidental capture close to the islands is not likely to occur because gill net use has been prohibited (since 1994) within one mile or in waters less than 70 fathoms deep (whichever is less) around the Channel Islands (FGC section 8610.2, as part of the Marine Resources Protection Act of 1990).

However, given the low estimated population size of Xantus's Murrelet and all of the other threats to the species, a chronic low level of bycatch could be a problem for the species. The Japanese Murrelet, an endangered species with estimated population size of less than 4,000, has been documented as bycatch in high-seas drift nets (Piatt and Gould 1994). This species has very similar biology to the Xantus's Murrelet, with breeding restricted to a few sub-tropical islands and birds generally moving northward after breeding, offshore in warmer waters. An observer program found a low but persistent rate of mortality in post-breeding areas that may be contributing to the species decline (Piatt and Gould 1994).

Summary of Threats

The Department finds sufficient scientific information to indicate that the identified threats have the potential for contributing to decline in murrelet populations. Peregrine Falcon predation on murrelets is potentially an emerging threat. The Department believes Bald Eagle predation may pose a problem in the future, but more information is needed.

Impact of Existing Management Efforts

The petition contains numerous statements indicating the inadequacy of existing management efforts: 1) lack of observer programs on squid fishing and gill net vessels; 2) park visitors have not been prevented from accessing sea caves or offshore rocks where murrelets nest; 3) lack of monitoring as to effect of light shields on squid vessels; 4) inadequate protection of nesting areas; 5) full extent of military operations and potential impacts to murrelets is unknown; 6) no attempt has been made to quantify the numbers and disposition of birds landing aboard brightly lit vessels and oil platforms near murrelet colonies; 7) no detailed studies have been conducted on the impacts of non-native mammals to murrelet populations; and 8) lack of a management plan to combat future rat introductions.

The petition also states "*An assessment of the true impacts of the many threats described here is further exacerbated by the lack of data collected by state and federal government agencies.*"